

1

Method of Operating
in the Melter and Refiner's Department
of the U.S. Mint at Philadelphia

Receiving Deposits.

Before the Deposits of Bullion are passed into the hands of the Melter & Refiner, they are received by the Superintendent's Receiving Clerk, in the presence of an Assistant, the Register of Deposits, & the Depositor himself, precisely according to the "Instructions for Transacting business at the Mint," the weights before and after melting being noted and recorded by two or ^{persons} ~~three~~ officially. The Register records his observations on the character of the metal deposited, its alleged origin, its absolute, ~~loss~~ loss in melting, & its calculated percentage loss. These elements are weekly discussed by the Melter & Refiner, and his Report made to the Superintendent.

The Melter & Refiner has nothing whatever to do with the Deposits until they have been melted, weighed after melting, and assayed, so that their exact value is known, except that, upon the requisition of the Foreman of Deposit-Melting, he may advise or suggest a special mode of melting & fluxing. On the soundest principles the M. & R. should not receive ^{nor hold} a deposit until

until he can be debited with its ascertained value.

Deposits transferred to the Melter & Refiner

The smaller deposits are daily transferred to the M. & R.; the larger deposits, purchases & transfers, ~~are passed to him~~ as soon as practicable after their arrival in the Mint. They are weighed ^{and delivered} to the M. & R., in presence of the Register, by the Receiving Clerk, the gross weight ^{being} silently observed and recorded by each of the three officials, & the recorded weight then called out ^{in order by the triple concord} to insure accuracy in the record. It has been noticed that where a weight is announced before recording it, there is a tendency to record the announced ^{figures} ~~weight~~, not only without observing the weight, but even after observing it, ^{and} altho it may be different from ^{the sum} ~~that~~ announced; hence the advantage of ~~the above~~ recording before announcement.

^{over} All the smaller deposits, & ^{many} ~~as far~~ as practicable of the larger ones, after weighing, are immediately transferred to the M. & R.'s vault, but in the present method of receiving large invoices of fine silver bars or pigs, & ~~for want~~ from lack of vault space, the remaining pigs, ^{over} of 100 lbs. weight each, are stored again in the Suptd's Vault, until needed for coinage, or until there is space in the M. & R.'s vault to receive

At the close of ~~each~~ weighing each lot of bars, or of each day's weighings, the whole lists are again compared by one reading aloud the noted weights, should any recorded weight lack the triple concord, that particular bar or bars is reweighed.

receive them. In recording the weights of the numerous silver pigs of an invoice, the record shows the Mint number of the deposit, ~~the~~ ^{& other mark} the number stamped on each bar, and ^{the} consecutive numbers ^{painted} on each pig ~~by in marking ink~~ by the M. & R.

The agreement of weight with markings will always identify each pig; this identification ^{together with} the great weight of each pig precludes error of ~~any~~ or evil of any kind arising from the necessity of storing the pigs in the Suptdt's vault, altho' officially they are in the hands of the M. & R.

After each transfer of bullion, the M. & R. ^{to the Superintendent} gives a Re-ceipt for the gross weight, and character of the bullion received. The M. & R. is however debited, according to law, only with the Standard Weight of Bullion, as soon as calculated from ^{the} gross weight & assay-fineness, by two of the Suptdt's clerks, (separately and by different methods.) When in active business, the M. & R. has not sufficient clerical force to calculate the standard weights, otherwise a third calculation ~~would be~~ is desirable & should be made.

Refining Bullion

The Deposits are assorted into fine & standard, which are melted into coin, ~~after proper~~ ^{into} and those which ~~are to~~ require

require to be refined by acids, in order to adapt them to ~~make~~ coin^{age}. Even some Silver Bullion, containing ~~chiefly~~ copper as its alloy, & in so far adapted to coin directly, ^{from the presence of minute quantities of embrittling metals,} may yet be so hard & brittle ^{make} as to ~~require~~ refining by acid, ~~is~~ more economical & effective than toughening by fluxion. Every gold deposit, reported by assay to contain silver, is subjected to refining by acid.

Refining Gold. ^{over} Gold deposits are assorted into lots, according to fineness, and so much silver added to each, that the ratio between gold & silver ~~(including baser metal)~~ shall be ^{about} 1:2. ^{Our} ~~The~~ usual melt of 2400 oz. therefore consists of about 800 oz. pure gold, and 1600 oz. silver ~~(baser metal)~~.

After being melted and thoroughly and continuously stirred by a black lead ^{stirrer to} insure the dissemination of the gold through every part of the alloy, the latter is dipped out by a black lead dipping cup, & either cast into bars of about 10 @ 15 lbs. weight, or granulated. In the last method it is cast from the height of several feet, & with a horizontal gyratory motion, into a large bulk of very cold water (in summer cooled by ice), whereby it congeals in thin feathery granules, presenting a greatly extended surface. The bars or granulations are ^{commercially pure} steamed for some five hours in ~~pure~~ nitric acid of 35° @ 40°.

but if there be much base metal (such as copper) with the silver, the weight of the two together may reach 2 1/4 or more, then 2 1/2 to 1 of gold, ~~base~~

(crude or melted)

Native gold ^{crude or melted} and gold residues from the arts ~~when melted~~ contain more or less silver, which, being of no value in gold coin, is previously extracted by parting, or refining by ~~acid~~ ^{the} chemical agents, ~~usually by~~ nitric acid, ~~or~~ ^{or} oil of vitriol, ~~or~~ ^{or} chlorine. ~~For this mint we prefer to~~ ^{we} refine by nitric acid, as yielding ordinarily a softer gold of 994 @ 996, ~~or to chiefly by nitric first by~~ & where we deem it expedient, we finish ~~this~~ ^{it} by hot oil of vitriol, thereby raising the fine gold to 998 @ 999½, & recovering ~~the~~ ^{the} ~~small~~ ^{small} remnant of silver, the difference ^{from native gold, the} between 994 & 998. The method ~~of refining~~ now the acids will not extract ~~the~~ ^{from native gold, the} small proportion of silver in it ~~in gold~~, & hence the admirable ~~quartation~~ ^{quartation} method of the alchemists termed "quartation", wherein one ~~part~~ ^{ounce} of gold was melted with ~~three~~ ^{three} ounces of silver, the gold constituting a fourth part (a quarter), & so disseminated ^{or diffused} among the 3 parts of silver, that ~~hot~~ ^{hot} nitric acid, or oil of vitriol which dissolves silver, but not gold, will dissolve not only the silver that ~~which~~ was added to the gold, but also that which was originally contained in the gold. The only change we have made in this process is ~~the~~ ^{by} diminishing the ~~quart~~ ^{quart} proportion of silver, ~~from 3 to 2 parts~~ making it about 2 parts or. silver to 1 or. gold, ~~which is a change which I introduced in 1850,~~ ~~which we have adhered to ever since,~~ a change which I introduced in 1850, which we have adhered to ever since, as being much more economical than the older method of quartation, & yet equally efficient.

@ 40° Beaumée in 20 gall. porcelain jars, the unsaturated acid of the previous operation being used economically on fresh metal to form a saturated solution of nitrate of silver. The solution is drawn off from the insoluble residue of tolerably fine gold, & is converted into fine silver, as below.

II. The gold residue, after washing with water, is ~~usually treated~~ ^{either steamed} a second time with nitric pure acid, ~~steam~~ whereby the gold is obtained of the fineness of 995, & the nitric acid reserved for the next lot of granulations; or the washed gold residue, whether treated the second time with nitric acid or not, is heated in iron boilers with oil of vitriol, usually in two successive charges, whereby it is brought, after washing, pressing, & drying ~~to~~ and melting, to 998 @ 999 $\frac{1}{2}$.

Refining Silver. All silver bullion containing gold, and even such as, without gold, is ^{be more economically} assumed to ~~require~~ refined by ^{than by fluxing} acids, ^{by} is refined dissolving ~~in hot nitric acid~~ ⁱⁿ with the same nitric acid, in the same jars, & in the same way, ~~also as above~~ ^{solution of} described for parting gold & silver. The saturated ~~nitrate~~ ^{solution of} of silver ~~solution~~ is transferred to a large wooden vat containing a sufficient quantity of a solution of common salt, ^{so that every practicable trace of silver is precipitated} as experience dictates, an excess being always employed. The chloride of silver, made to settle by agitation, is ^{the washings} run off into large pitters, washed until ~~it ceases~~ ^{to} redden

red den litmus paper, and transferred into a lead-lined wooden vat, where it is reduced to metallic silver by granulated zinc of the best commercial quality. ~~The amount of zinc~~. A large excess of zinc is employed to shorten the time of reduction, & the excess dissolved ^{out} by sulphuric acid. The pulverulent reduced silver is ~~filter~~ washed thoroughly on a filter by hot water, until the latter ~~it~~ ceases to give an acid test, after which it is ^{drained} pressed, dried & melted, yielding bar silver of .998 @ 1000. by melting, without or with very little fluxing. (over)

Up to the year 1851 ordinary zinc ^{used} being ~~used~~ ^{employed} for refining gold, I had many tons of silver ~~and for refining gold~~ which averaged about 995, but upon ^{introducing only} ~~using~~ the best zinc, which I had cast especially for this Mint in Belgium, the average fineness rose immediately to 998. Now, with the best American zinc, we attain the fineness of 999 ~~with~~ or higher without difficulty,

and in the year 1870 we delivered to the public 83,549 oz. of silver ^{bars} 1000 fine, ^{which means} ~~of~~ absolute purity. ^{We believe it to be the only instance on record in which more than 20 or 30 oz. of silver was made of absolute purity at one period of time.}

Pressing and Drying ~~Pulverulent~~ pulverulent gold & silver ^{by me} ~~is~~ ^{their} ~~resor~~ was adopted in 1850, as a remedy against loss by in the form of dust, & has amply repaid the cost of the machine arrangement. If the powdered metal, however thoroughly dried by warmth, be put into the melting pot, it boils, often

The operations of precipitating, ~~the~~ washing & reducing chloride of silver & ~~was~~ of washing the reduced silver may ~~be~~ be so facilitated by mechanical appliances, as to reduce the time of recovering ~~pure~~ silver in ~~its~~ ^{the} metallic ^{state} form from its solution from 48 or more hours to ~~5 or 6 hours~~ less than six ⁽⁶⁾ hours.

often violently, from the escape of steam, which carries the fine dust up the chimney flue. Some of it out of the chimney into the air. To obviate this, ^{danger of loss} the reduced and washed ~~silver~~ metal is pressed in a powerful hydraulic press into flat cylinders ^{or cakes} ~~which~~, which are dried on a shallow pan of heavy boiler-iron at a low red heat, until a piece of sulphur passed across the ~~cake~~ ^{cake} leaves its blue line of flame, ^{indicating sufficient dryness.}

The ~~cakes~~ ^{cakes}, weighing 35 or 40 lbs. in silver, & nearly twice as much in gold, are simply broken by hammer & chisel into lumps which are directly melted ^{in a crucible} with a little borax ~~flux~~ into bars of ~~pure~~ fine silver.

Refining Account. A special refining account is kept ^{by debiting the} ~~Refinery~~ ^{with all} the gold & silver sent into ~~the Refinery~~ it, each bar or lot being entered separately into the account in gross weight, fineness and standard weight. The Refinery is credited with all the gold & silver, refined, ^{weighed, assayed,} melted, & calculated to standard, which it returns to the vault. A summary of the Refining appears also ~~in~~ ^{as} a special item in the Vault Account. The balance between the D^m & Cr, shows that in general the act of refining is attended with little loss. Where the deficit is larger than ~~it should be~~ it should be, a minute investigation discovers the cause of the apparent or real loss, & thus indicates a remedy when ^{if any be needed} ~~when~~ ^{melting}

Melting Standard Ingots

The U.S. Standard for gold and silver being 900 m pure to 100 m alloying metal, the relative quantities of these must be calculated and weighed out for a given quantity of alloy, ~~the highest limit of which that~~ ^{that} quantity which is melted in a crucible at one time. The quantity of precious metal in each mass of silver from the mines is determined by assay, ~~and is the balance is the in expressed as~~ ^{and is} such & such fineness, meaning the number parts of pure metal in each 1000 parts of the mass; the balance is assumed to be alloying metal, oftener expressed as alloy. Since the different pigs, or bars, or lumps of ~~met crude~~ ^{met crude} bullion vary in fineness, each melt requires ~~one or more~~ ^{a separate} calculation for each pig, of which it is to be composed. When the standard Ingots, cast from a melt, are rolled ~~into strips, & the small~~ ^(of the coin disks clipped out the) disks or blanks for coin are cut out of them, the residue residue, termed ~~clippings, from clipping~~ ^{clippings}, ~~from cutting out the small disks for coin, are too~~ ^{from cutting out the small disks for coin, are too}, is returned to the M & R. ~~to be remelted~~. In point of fact, about one half of the standard metal is ~~thus~~ ^{thus} returned, to be remelted, & in like manner the half of each successive residue. Hence each piece of metal $\frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \frac{1}{32} + \dots$ ~~and so on~~ ^{number of times,} is thus melted ~~& $\frac{1}{2}$ and $\frac{1}{4}$ and $\frac{1}{8}$ and $\frac{1}{16}$ and $\frac{1}{32}$ and so on~~ ^{being just}. The sum of an infinite series of ~~one~~ ^{one} successively halved ~~is~~ ^{is} equal to 2, All the standard metal

~~metal~~ ^{metal,} standard melted for coinage, is melted at least twice.

~~Q for the reason just stated~~
 In calculating & making up a melt for Ingots, ^{only} about one half of the amount ^{of new metal is used,} required, is the other half consisting of clippings from previous workings, ^{for} experience ~~having~~ shown that clippings tend to soften new ^{ly} made alloys

The M. & R. ~~Assistant~~ ~~M. & R.~~ weighs out the due quantity of bullion for a melt, ^{he & the weigher reading the weight separately,} ~~has the weight twice~~ ^{to insure accuracy,} ~~read, by himself and the weigher,~~ ^{the weight,} and enters it in the "Working book", arranged for the ~~purpose~~ purpose, and puts the bullion so weighed into a copper-lined box. The M. & R., having calculated accurately the amount of copper or of ^{fine} ~~the~~ bullion, (as the case may be,) required to bring each melt to standard fineness, weighs it out, & adds it to the box containing that melt. The gold and ^{& incapable of minute subdivision,} silver being ^{usually} in bars, the copper is made flexible, ~~to~~ by ~~the~~ having a stock of it divided ~~up~~ into assorted fragments down to .01 ^{oz. and less.} ~~(100) of~~ ~~ounce~~. The best commercial copper, ($99\frac{1}{2} @ 99\frac{3}{4}$ pr. ct. pure, by ~~the~~ analysis of extreme accuracy), occurring in bars of 12 @ 15 lbs. weight, is ^{partly} cast into ~~thin~~ bars of $\frac{1}{8} @ \frac{1}{4}$ inch thickness, & some of these again sheared into ~~piece~~ smaller clips, and ~~partly~~ ^{partly} ~~into~~ is cast into very cold water (using ice in Summer) to granulate it into shot of very conceivable size, from ~~that of~~ fine sand to ~~that of~~ Cover

Buck-shot. A special account is kept of the Copper used for alloying Gold and Silver.

The calculation of the quantity of alloying copper, or of fine bullion, requisite to make standard metal, is ~~not~~ made by the M. & R. or Assistant M. & R., because extreme accuracy is desirable, and, when business is very active, rapidity is also ~~requi~~ needed. only one person ^{however} seems to be necessary for the calculation, for we have not found a single error in many thousand of our calculations.

19
When a carload of such melts is made up (usually 10 @ 15 melts, or when business is very active ^{two} ~~for~~ more car-loads) it is drawn into the Vault, to be taken out for melting on the following morning.

Making Gold Ingots

Black Lead crucibles of No 70 size ^{are} used to melt the alloy for ingots, the total weight of each melt being 4000 @ 4500 oz. of standard gold (900 fine). The quantity of copper, calculated to bring all the gold exactly to 900 fineness, is weighed with precision to the $\frac{1}{100}$ oz., and the weight read separately by two persons.

A part of the fine gold and all ~~this~~ copper constitute the first charge put into the melting pot, & after melting they are ^{thoroughly} stirred. This first

charge is ~~thoroughly stirred~~, ^{because the smaller quantity allows of more ready stirring} because the wide difference in the specific gravity between gold and copper ($19\frac{2}{10}$ and $8\frac{7}{10}$) demands

that the first charge be most thoroughly stirred to insure their perfect blending, & ~~thereby~~ ^{thereby} a more easy incorporation with subse-

~~quent charges~~. The balance of the fine gold is next added, & after melting, the whole is again well stirred. Lastly any other ^{standard} metal or clippings is added, melted & the whole stirred. A portion of clippings is reserved to lower the temperature of the metal to the best casting heat, just before & during casting.

This method of ^{first} melting all the copper with a part of the fine metal ^{in the first charge} secures a more perfect alloyage, than if all the fine metal and its copper had been melted at once, ^{moreover} ~~because~~ this first alloy having ^{over}

a much greater specific gravity than copper will blend ~~it~~ more readily with the still heavier fine gold next to be added.

¶ It is generally received as experience that the union of gold and copper is very firm, and that their alloy is scarcely ~~is~~ liable to segregate into richer & poorer alloys, but I am unwilling to accept this conclusion as the result of my experience, without the following limitations. The presence of small quantities of foreign matters, antimony, &c. seems to increase the tendency of copper and gold to segregate. When gold & copper have been well alloyed by stirring in the crucible, there seems to be no tendency, or at most a feeble one, to segregate, while kept melted or ~~while~~ ^{during} casting; but when scraps or even bars of such well alloyed metal are ^{again} melted by a moderate heat, they do in fact often ~~and~~ segregate into richer & poorer alloys.

(especially where the heavy ^{melted} gold is liable to ~~set~~ ^{cleave to the bottom of the crucible} at the rest
 Since stirring alloys is important to secure their perfect blending, ^{(as a stirrer}
~~set~~ under the lighter copper.)
 I contrived a black lead paddle with a few holes in the lower end, to
 stir the whereby the liquid metals are divided into many streams,

and so more surfaces of contact being formed, the two metals are more & more rapidly certainly blended into one alloy. Experience confirms its ^{efficiency} ~~utility~~.

Clean powdered charcoal is continually kept on the surface of the metal during casting to prevent oxidation & burning off of copper; and to avoid loss by volatilization, the draft of the furnace is closed by a damper, so that any possible fumes

fumes ~~may~~ escaping into the ~~me~~ air of the melting room may deposit their metallic dust, & so pass into sweep.

The ~~melted~~ mouth of the furnace is closed by ~~an arrange-~~
ment termed a "melting hood", consisting of ^{a sheet of} boiler iron, which fits over the whole opening, except that ^{an open} cylinder, is of the crucible, ~~inserted in the middle rests upon the to rim of the crucible.~~

So that the caster is screened from all the heat of the opened furnace, except that radiating from the surface of the melted metal, which ~~he dips~~ ^{last the ladles} out with a black lead "dipping cup" held in tongs, & pours into the greased molds. For greasing, lard, lard oil, sperm oil, or petroleum are employed, the last being superior in cleanliness, keeping molds clean, & less liable to form the hard carbon deposit to which the others are liable.

The ingots coming hot from the molds are dipped for a few minutes into water, acidulated with sulphuric acid, whereby their surfaces are made clean & bright, & are then cooled & washed in ~~the~~ cold flowing water. After cutting off the tops (or pouring gates) of the ingots, and filing off their feathered edges, each ingot of a melt is stamped with figures representing the assay number of that melt from the beginning of the year.

Pieces are chipped off by the Assayer from the first and ^{cast} last ingot of a melt, marked 1 & 2 of that melt, and the result of their

of their assay, ~~determines~~ ~~is assumed to~~ determines whether the melt is of legal standard or not. If ~~both~~ ^{the two} assays ~~are~~ be sufficiently accordant, all the intermediate parts of the melt are assumed to be intermediate in fineness, & all experience has shown that this assumption is safe. The maximum & minimum fineness of our ^{Gold} ingots is rarely outside of 899.9^{gm} and 900.1^{gm}, and our practice is not to allow a greater variation than 899.7^{gm} and 900.3^{gm}, or a ^{nextreme} deviation of $\frac{3}{10,000}$ ^(.0003) from ^{the} standard fineness.

Making Silver Ingots

Copper Alloy

The quantity of copper required to ~~bring~~ ^{make} silver coin of the ^{U.S.} legal standard, 900^{gm}, is different from that ~~for~~ ^{in the act of congealing, a} ~~require~~ what gold requires. First, because, when a silver ingot is cast, ~~the~~ ^{normal} segregation throws of ~~copper~~ silver-copper alloys throws a richer alloy to the central line of the ingot, & a poorer outside of it; & therefore, since the coin are cut out from the centre, the whole ingot, & of course, the whole melt of ingots, must be made ~~poorer~~ ^{by an excess of copper in order to} lower than 900^{gm} to cut out ~~the~~ coin of 900^{gm}. — Second, because, ~~in~~ ^{while} melting ingots, there is a tendency to ~~the~~ oxidize & burn off traces of copper, therefore a ~~trace more of copper should~~ sufficient copper should be added to replace this waste. Third, because, ~~in the~~ ^{to clean} ~~the~~ blanks ^{before stamping} they are plunged while hot into dilute sulphuric acid, whereby copper is extracted from the ^{ir} surface, to a depth depending on the strength of acid and time.

and time of immersion. I determined long ago from sheer experience that to obtain coin of 900^m the alloy should ~~be~~ ^{not} be above ~~but not~~ ^{& exact} 899^m, but the more direct, experimental determinations ~~made~~ ^{several years ago} ~~by~~ ^{since by} Dr R.E. Rogers & myself, proved that ~~so~~ much copper should be added to silver as to make the ^{whole} alloy average 898 $\frac{3}{4}$ ^m. We have followed this formula for some years, & the average fineness of 900^m in our silver coin proves ~~the~~ ^{its} soundness of the under present modes of working. ~~our melts of standard silver are all weigh about~~ melting ~~casting~~. We usually cast from each melt of standard silver about 3500 oz., which by topping & filing is reduced to about 3300 oz. of ingots for the dollar & rather less for the quarter dollar. The melts are made in ~~N^o 70~~ Black Lead pots, N^o 70, of very full size, a loose black lead ring ~~of~~ (4 inches high) being put on the top of the crucible & the cover on the ring. This virtual elongation of the ~~the~~ crucible encloses the whole of the ^a commercial pig of ~~the~~ silver, so as to exclude the sulphurous fumes of burning while melting, & the liquid metal sinks below the rim of the crucible ~~at~~ anthracite. The ring offers the further advantage of allowing more thorough stirring without danger of ~~splashing~~ ^{splashing} metal into the fire. A piece of black lead (usually the inverted bottom of an old crucible) is put in the bottom of the melting pot as a stool for the large rectangular pig to stand on while melting, lest

lest its weight, (100 lbs. more or less), should press the solid angles through the ~~both~~ sides of the crucible.

The ~~metal~~^{pot} is charged similarly to that ~~of~~^{in melting} gold, a part of the fine metal, if practicable, & all the copper being first charged, & melted, before the rest of the fine metal, & lastly the clippings are ~~also~~ put in. The little flux, ~~from~~ which facilitates fusion, protects in a measure against oxidation & volatilization, & more or less prevents blistering, is skimmed off, when the fusion is complete, & the metal well stirred, and its total removal is effected by the addition of fine charcoal, to which the remaining flux adheres, so that both are easily & completely skimmed off, leaving a brilliant surface of metallic silver.

Casting. The metal is immediately covered with fine charcoal, which is continually added during casting, ^{to replace what} ~~it~~ burns off, so that in the atmosphere of carbonic oxide & acid, ^{& by the covering of charcoal} both oxidation & volatilization are ^{lessened or} measurably prevented. ^{altho'} Silver, having half the specific gravity of gold, is more easily ~~and sufficiently~~ stirred, so that a thorough blending of the metals into a homogeneous alloy is more certainly secured, nevertheless such is the strong tendency of standard silver alloy to segregate into richer & poorer alloys, both in the melting pot & in the act of congealing, ^{to obviate the tendency} that special precautions and watchful care are demanded.

Segregation and True Assay of Coin-silver

~~Altho~~ The general fact of segregation ^{of alloys at the time of congelation} has long been known in a silver ingot ~~at the~~ of an alloy, in the central line richer in silver, ~~on the outside~~ and a law of distribution ~~of poorer & richer alloys of silver & richer poorer in silver & therefore richer in copper~~. ^{in a} copper was determined ~~by~~ ^(long ago) the Assay Department of this Mint. This mode of segregation we may term normal, & the difference between the ~~yet its influence & importance has been increasingly acknowl~~ centre & sides may be stated roughly at ~~so 1000~~ ^{over} ~~edges to this very year~~. Not many years since it was proved that the method in use up to that time, of chipping off a slip from the first & last ingot of a melt, for assay, did not give the true average fineness of the metal. The method was then ^{over} adopted, which has ever since continued in use, when beginning to cast the metal after thorough stirring, to cast an ounce, more or less, into water to granulate it, and to do the same just before finishing ^{granulations} the casting. The instantaneous congelation of the ~~castings~~ ^{insures} prevents segregation, so that their assay represents the true fineness of the ingots. The uniformity in the assay results of these two granulations may be presumed to exhibit the true fineness ^{if it has been often stirred.} of all the intermediate metal. Even when this method is practised, the necessity of thorough ^{& frequent} stirring is shown by the fact, that a large mixture coin of different dates in the same year, each melt of which ^{had been of} ~~was~~ standard fineness, and ^{the mixture} therefore the most perfect average of 900 practicable, was melted, ^{stirred} & granulated, as above, the 1st & last granulations showed a variation from each other of five ^{thousandths}.

Segregation and True Assay of Coin-Silver

The fact of a tendency in alloys to segregate has long been known, and the law of segregation in an ingot of standard silver, when in the act of congealing, ~~has been~~ was long since determined in the assay department of this mint, according to which ~~and~~ a silver-copper alloy, richer in silver, collects along the central column & a poorer one ~~on the~~ towards the outside. ~~This which we term~~ ^{We may term this termed this} normal segregation, and ~~the~~ in which the interior of an ingot is about 1000 ^{for a long time} richer in silver than the ~~rest~~ exterior, & its ~~was~~ ^{part} regarded so uniform, that pieces of ingots were chipped off from a certain ~~part~~ for assay, to determine whether the ~~can~~ ^{metal was} ~~would be~~ standard or not. ~~fineness~~ for coin. A few years since it was proved that ~~the~~ ^{fineness} ~~this mode~~ such assay did not represent truly the fineness of the ingot & therefore of the coin. In fact segregation has been more irregular ^{more frequent} latterly than formerly, & is in my ~~belief due to~~ opinion due to the ^{presence} of small quantities of foreign metals, antimony, bismuth, &c. which render segregation more abnormal. ~~than formerly~~.

(.005)
thousandths, fairly ascribed to the melter having waited
some time after stirring before casting the granulations.
To test this, the same metal was again melted, ^{I kept} stirring ~~immedi-~~
~~ately~~ during the whole casting, when the ^(resultant) assays of the 1st and
last granulations were practically identical, & that was good.

Remedy for Abnormal Segregation
Stirring Silver Ingot Melts

Preventing Segregation and Remedy for

Stirring silver ingot melts immediately before casting is of
sufficient importance to demand ^{a more detailed description of the method of} ~~more detail~~ ~~going to~~ remedying
~~for segregation~~ ^{Stirring} ~~more in detail~~. Constant agitation until ~~a~~ It is the more im-
portant at present, because most of the commercial silver from
the Refineries retains a small percentage (one or more thousandths)
of base, & usually of embrittling, metals, ~~As~~ Arsenic, Antimony,
Bismuth, Lead, &c. which, in my view, tends still more strongly
to ^{induce} the segregation of silver-copper alloys, than if pure ~~cop~~ silver
& copper alone were present. The moment the melted alloy becomes
quiet, segregation begins. It is therefore necessary not only to
stir the metal just before beginning to cast, but to keep up
the agitation without ceasing until ^{all} the ~~silver~~ metal is cast
out. This is effected ^(during the casting) ~~by~~ ^{specially} by a stirrer, or by thrusting the
dipping cup up & down ~~in the~~ through the melted metal, -
or by dipping a cup of melted ~~the~~ metal, & pouring it from
a little height into the balance of the metal in the pot.

Even after the above precautions, we always leave a portion of silver ^(200 @ 300 oz) in the ~~pot~~ melting pot for the next melt, because the length of time required to dip out the last remnants by dribblets would be most likely to induce segregation, and would certainly expose the silver to volatilization, ^{For} ~~because~~ as the silver in the pot diminishes, while the fire remains the same, the relatively greater bulk of the fire has the effective result of ~~increasing~~ ^{even rising to a greater} the heat ~~even to~~ volatilization of silver.

Standard Silver Ingots. When cast, the silver ingots are treated similarly to those of gold, dipped into diluted sulphuric acid, washed, topped, filed on their edges, wiped & dried, the only difference being that only the top layer of ingots in a box, ~~not the~~ ~~are~~ are stamped with the number of the melt, & not every ingot. Since an ingot of the fineness $898\frac{3}{4}$ will make coin of 900, it is the usual practice of the Assayer, not to certify to the legality of ingots ^{the standard of} outside of 898 or 900; ~~In~~ point of fact, a large proportion, say ~~the~~ nine-tenths ($\frac{9}{10}$), of our silver ingots fluctuates between $898\frac{1}{2}$ and $899\frac{1}{2}$, far within the legal limits; and hence the ~~the~~ uniformly close approach of our coin to 900.

Transference of Ingots & Clippings

The Superintendent mediates in transferring Ingots from
the melter

the Melter & Refiner to the Coiner, and Clippings from the latter to the former, all three officers or their delegates being present at ~~or~~ ^{the whole time of} and during each transfer. The Suptdt's ~~clerk~~ clerk weighs the bullion; each of the three deputies reads & ~~puts~~ notes down the weight, after which the weight is read aloud. Disagreement in weights is rectified by reweighing. Melts of gold ingots are weighed singly, but melts of silver in masses of some 5000 oz. each. The entries in their respective books consist of the date of entry, the number of the melt, if gold, the number of the draft at that weighing, the description of the bullion, (clippings, ~~and~~ number & denomination of ingots), and the weight. At the close of the transfer, the sum of ingots, and of ounces is noted by each delegate, and then read aloud, so as to secure the accuracy of the whole transfer. Summaries of deliveries are compared monthly or oftener.

Full receipts are given at the close of each delivery, by the Suptdt. to the M. & R. for Ingots ~~and~~ ^{and} Fine Bars, and by the M. & R. to the Suptdt. for clippings.

Daily Record of Melting Bullion.

An account is kept by the M. & R. against the Master Melter of the amount of bullion sent to the Melting room each

each morning, such as, the residues from the previous day's work, clippings sent out to be melted, melts made up with the due proportion of ~~bullion~~ alloy, and other bullion calculated and made up by copper or fine silver ~~to~~ (as the case may be) to the standard of $898\frac{3}{4}$. The master melter is debited with all the above. At the close of the day, he is credited with all the residues, with the weight of ingots made, (when delivered to the Supt. dt.), & of any condemned melts, & of the grain-bar of that day. To render the account more truthful and exact, all the items above-named are calculated to the regular standard, 900, the ingots, bars & tops, filings, & prepared melts being assumed at 899, the clippings at 898, & the rest ~~calculated~~ ^{reported} calculated at ~~the fineness of the report~~ reported by the Assayer. The balance between the debit and credit accounts show the losses of the day's work with sufficient nearness to truth to determine whether they are usual or excessive. The only items omitted from this daily account are the daily bar of grains (not known until the 2nd or 3rd day after melting), a bar of general grains, determined ^{bullion adhering to iron utensils, grate bars, &c} once a month, the assay-slips, and the sweep.

over ~~the~~ Daily Grains. At the close of a day's work, the sweepings of the stone floor under the iron-grated floor, from near the furnaces & filing benches, & the slags skimmed from all the melts of the day, are put into an old melting pot, & left to king in a

Assay Slips. : ~~Q~~ An account is kept by the assayer of the ~~ass~~ ^{daily} slips cut off from Ingots & other bullion in the hands of the M. & R., but as portions of them pass into solution in the course of the assay, & as it would be impracticable to recover these trifling items daily, a cumulated return of them ^{is} made by the Assayer to the M. & R. once or twice a month.

losses, which are further reduced by the sweep and the amalgam.

~~Separation~~ ~~Sweep~~ of Iron residues. When a pot ~~By the~~

In the use of tongs & other iron utensils, or when a pot of melted metal breaks over the grate-bars, the bullion adhering to the iron is removed ^{by cutting & scraping} as far as practicable at the time ^{is} put among the grains. The ^{remaining} iron containing traces of ^{bullion} ~~the metal~~ from several such operations to be worked at one time, to recover ^{all} the precious metal. The former ~~simple~~ method is to melt and ~~king~~ the whole, with sufficient carbon of recovery ^{by heating} ~~was to heat~~ the iron to full redness, until all the ~~scattered~~ parts containing bullion ^{were} ~~sc~~ scaled off by the hammer, causing a loss of bullion by long heating in the fire, and usually ^{by a large force of men} three days of labor, once a year. D. The second process, which I contrived, ~~was to~~ ~~scattered~~ sulphuret ~~the iron~~ ~~from the whole~~, and to remove ~~the sulphuret~~ it again by solution in acid, leaving the gold and silver, ^{untouched} was more easy of execution, & saved loss of bullion, but was rather too costly in acid. I then contrived the method now ~~adopt~~ ^{in which by} employed, ^{ing} to melt the iron well carburized and ~~king~~ it allowing to king in a slowly lessening fire, the bullion will be found in a layer under the iron, & entirely separate, & easily detached from ~~each other~~ it. These pieces of bullion ~~are~~ usually brought into pass to the credit of the M. & R. once in the year, or as often as obtained.

The residues of grinding, noted above as finally passing through sieves (up to No 60) in a dry state, are passed through a washer & amalgamator, suspended in a constant stream of water, from which the fine grains (as above noted) deposit. The stream, with the still finer balance, is forced, under constant stirring, through mercury, which takes up a portion of gold & silver. The pressed amalgam is usually distilled once in a month, and its melted bar assayed, numbered & named Amalgam-bar. The fine matter, passing from the mercury, is sweep suspended in water, and flows into ^{& through} a settling tank, a wooden box lined with sheet-lead, & divided into three compartments by partitions of sheet-lead.